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ABSTRACT

The subscales of the How I See Myself Scale were originally established by using a principal components analysis on item scores for a sample of 4,217 elementary school children in grades three to six. A re-analysis of the same data using a common factor solution (using test communalities instead of units in the major diagonal of the correlation matrix) resulted in a somewhat different assignment of items to subscales. The new subscales had fewer overlapping items and better correspondence with the judgments of a panel of 10 expert judges concerning the appropriateness of items to scale constructs. Finally the analysis of a cross-validation sample showed the new subscales to be, in general, more homogeneous than were the original subscales. The revised test manual will incorporate the new subscales. It is concluded that the choice of analytic method can have important substantive effects on the results of a factor analysis. Tables present reliability data and a list of items which, for boys and girls, and for both methods of factor analysis, correspond to the subscales: physical appearance, academic adequacy, teacher-school adjustment, social confidence, and emotional adjustment. (CTM)

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CONSTRUCT VALIDITY: CHOOSING THE APPROPRIATE FACTOR ANALYTIC SOLUTION FOR DEVELOPING SUBSCALES ON A SELF-CONCEPT INSTRUMENT[1]

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CONSTRUCT VALIDITY: CHOOSING THE APPROPRIATE FACTOR ANALYTIC SOLUTION FOR DEVELOPING SUBSCALES ON A SELF-CONCEPT INSTRUMENT[1]

ABSTRACT

This study illustrates the importance of selecting the appropriate factor analytic method for construct validation. The How I See Myself Scale, elementary form, consists of 40 items, originally assigned to subscales through a principal components solution. Data from the original norm population (n = 4,217), were reanalyzed using a common factor solution. New subscales derived from this solution were compared to original subscales on three criteria: logical consistency of items within a subscale; number of overlapping items on subscales; and internal consistencies determined for a cross-validation sample (n = 448). In general, subscales derived from the common factor solution had greater construct validity.

Objectives of the Inquiry

The purpose of this study was to illustrate the importance of selecting the appropriate factor analytic method in the development and construct validation of an instrument. Although a well-known self-concept scale has been used, for purposes of illustration, many other scales which purport to measure other multidimensional traits could have served as well. The paper is not addressed to theoretical psychometricians or factor analytic experts, but rather to the audience of measurement practitioners, who in increasing numbers, are employing factor analysis in test development and validation.

Shavelson, Hubner, and Stanton (1977) have reviewed the construct validity of five major self-concept instruments used in the U.S. They noted that: (1) according to most theorists, self-concept is organized or structured, and multifaceted; and (2) the construct validity of self-concept instruments has been pursued by logical, correlational, or experimental procedures. When the researcher desires to establish the structure of multifaceted nature of his concept, factor analysis is often the analytic technique chosen. Such was the purpose of Gordon (1968) and Yeatts (1967) when they attempted to validate the How I See Myself scale (HISM), using factor analysis. (A more detailed description of this instrument is provided in the following section of the paper.) Shavelson et al. (1977) criticized the construct validity of this instrument on two counts: (a) Many items loaded on factors to which appeared to have no logical relationship (e.g. an item which reads "My skin is nice-looking" was keyed to the "academic adequacy" subscale; and (b) the same items were often keyed to several different subscales, thus hindering clearcut interpretations. Shavelson, et al. (1977) seemed to assume that these problems resulted from the nature of the items or the basic flaws in construct definition. The reviewers failed to note, however, that a third possible cause of these

problems could have been the type of factor analytic solution used.

The purpose of this study was to employ an alternative factor analytic solution, using the basic norm data for the HISM. The hypothesis was that, with no changes in the item content or subject responses, but only application of a more appropriate analytic procedure, the evidence for the scale's construct validity could be substantially improved.

Instrument Used

The How I See Myself scale, elementary form for grades 3-6, was used in this study. The scale has been widely used to measure changes in self-concept brought about by planned intervention programs. The scale originally was developed by Gordon from a set of responses by children in compositions about themselves. The item format consists of 40 bipolar statements (e.g. "I get along well with teachers" and "I don't get along with teachers."), which are connected with a five-point rating scale on which the subject rates himself in relation to the two statements. Test-retest reliability coefficients reported for total scores ranged from .78-.89. Items were keyed to one or more of the following factors (or subscales): (1) Teacher-School; (2) Physical Appearance; (3) Interpersonal Adequacy; and (4) Academic Adequacy with two additional unique factors for males only. Unfortunately the interpretive value of these original subscales was greatly diminished due to the small number of items on some subscales; the lack of logical relationship between some of the items assigned to the subscales; and overlap of many items between several subscales. (The objective of this study was to attempt to eliminate or reduce these problems by reassigning items to subscales using a different factor analytic solution.)

Methods of Analysis

The basic purpose of factor analysis is to identify the number and nature of dimensions underlying a larger set of variables. When this procedure is applied to a single test composed of n items, the test developer hopes to identify a reduced number of k dimensions (or factors) which can be used as a basis for grouping the items into subscales. The term "factor analysis" actually refers to a variety of different procedures. In general these procedures involve three similar steps: (1) preparation of a correlation matrix between the initial set of n variables (or items); (2) extraction of the initial factors; and (3) rotation of these factors to a terminal solution which provides maximum interpretability. Different factor analytic procedures vary with respect to how they accomplish these three steps (Nie, et. al., 1975). The purpose of this study was to illustrate how application of two different factor analytic procedures to a common set of test items could affect the construct validity of the subscales produced.

The two factor analytic procedures compared were both variations of a "principal factor" solution (Harman, 1967). The principal factor solution is designed to maximize the amount of specific variance in n variables which can be accounted by a set of k factors. When this procedure is applied to an item correlation matrix, the first factor extracted consists of the weighted linear combination of the items in the correlation matrix which will maximize the squared correlations between individual items and the factor. The second factor is subsequently derived to account for as much of the residual variance in the correlation matrix as possible. This procedure is continued until the desired number of factors has been extracted.

The original norm group for the HISM, Elementary form, consisted of 4,217 children in grades 3-6 (2,177 males and 2,040 females). To determine

the underlying structure of the trait as measured by this scale Yeatts (1967) conducted a principal components analysis. Using this approach, the correlation matrix prepared in the first step has values of 1.00 as the diagonal elements. Using principal components analysis, each factor is extracted to account for as much of the total variance as possible. The total variance includes both common variance (variance that is shared among the items) and unique variance (true-score variance that is specific to particular items and error variance).

Data from the original norm group were reanalyzed, in this study, using a "common factor" solution. This solution is distinct from the principal components solution in that factors are extracted from only the common (shared) variance among the items. This is accomplished by inserting communality estimates as the diagonal elements in the interitem correlation matrix. Because Yeatts originally assigned an item to a subscale if the item had a loading $\leq .30$ on that factor, the same rule was applied for assigning items to subscales created by the common factor solution.

Three criteria were established to compare the construct validities of the subscale patterns that emerged from the two analyses. The first two criteria were those used by Shavelson, et al. (1977) in their review of the HISM. The first criterion was that the number of items having no apparent relationship to the subscale to which they were keyed should be minimized. This criterion measure was obtained by having a panel of 10 expert judges review the items assigned to each subscale (without names) and identify items which they thought were inappropriate for that subscale. The second criterion was that the number of items assigned to more than one subscale should be minimized. A third criterion, was the internal consistencies of the subscales produced by the two different solutions. An independent cross-validation sample of 448 children (grades 3-6) was used to determine the internal consistency estimates of the subscales.

Results

Basically there was great similarity of the factor structures derived by the common factor and principal components methods. The specific items assigned to the various subscales by each solution are identified in Tables 1 and 2 for females and males respectively. For females, the major differences were:

(1) Only four factors were extracted from the principal components solutions while six factors were extracted from the common factor solution. (In both the Yeatts study and the current study, factors were rotated to orthogonal varimax criterion.) Yeatts did not report the amount of variance accounted for by her four factors, but in this study the six factors extracted from the common factor solution accounted for 26% of the total variance and 83% of the common variance after rotation.

(2) Subscales created by the prinicipal components solutions were longer than those created by the common factor solution.

(3) Subscales created by the common factor solution were more homogeneous in content than were subscales created by the principal components solution. A majority of the panel of expert judges identified eight items as possible "misfits" in terms of their logical relationship to other items on the subscale for the principal components solution and six items as possible "misfits" for the common factor solution. (These items have been followed by a question mark in Table 1.)

(4) Six of the forty (15%) items were assigned to more than one subscale using the common factor solution, but eleven (27.5%) of the forty items were keyed to more than one subscale, using the principal components solution.

(5) Internal consistency estimates for the subscales computed for an independent cross-validation sample of 174 girls, grades 3-6 (from the Daytona

Beach, Fla., public schools) are reported in Table 3. Because the number of items varied among subscales, actual reliability estimates are reported as well as reliability estimates projected for 10 items, using the Spearman Brown Prophecy formula. This Spearman Brown projection was applied to facilitate comparison of internal consistency for subscales of different lengths. For the four subscales created by principal components solution projected coefficient alpha values ranged from .59 to .73. For the same four subscales created by common factor solution, projected coefficient alpha values ranged from .67 to .77.

For the male norm group, an even greater similarity of factor structures was observed (see Table 2). The major differences for the subscales derived by the two different factor analytic solutions may be summarized as follows:

(1) Essentially there was no difference between the male and female subscales developed by Yeatts from the first four factors of the principal components solution, but two additional factors were derived for males only. For the common factor solution, however, six factors emerged for the male sample, similar in composition to those developed for the females. The six factors derived from the common factor solution in this study accounted for 25% of the total variance and 83% of the common variance after rotation.

(2) Subscales created by the principal components solution were again slightly longer than those created by the common factor solution.

(3) Subscales created by the common factor solution were more homogeneous in content than were the subscales created from the principal components solution.

A majority of the panel of expert judges identified ten items as "misfits" on the subscales derived from the principal components solution, but only four "misfits" on the common factor subscales. These have been denoted by a question mark in Table 2.

(4) Four of the forty items (10%) were assigned to more than one subscale using common factor analysis, but eleven of the forty items (27.5%) were assigned to more than one subscale using principal components analysis.

(5) Internal consistency estimates for the subscales, computed for an independent cross-validation sample of 274 boys, grades 3-6 (from Daytona Beach, Fla., public schools), are reported in Table 4. Again both actual internal consistency coefficients and internal consistency coefficients projected for 10-item subscales are reported to facilitate comparisons across subscales of different lengths. Projected coefficient alpha values for subscales developed from principal components analysis ranged from .59 - .79; for the subscales developed from common factor analysis the range was .66 - .79.

Discussion

Factor analysis as a method of test validation was once considered so complex and time-consuming, that only a handful of experts were prepared to use it. Today, however, with the widespread availability of packaged computer programs with factor analytic routines (e.g. SPSS, SAS, BMD, etc.) many educational researchers and measurement practitioners are now able to apply these procedures to instrument development, even though they may have limited understanding of the mathematical models that underlie the various factor analytic solutions they choose to employ or the possible consequences on instrument validity. The findings of this study should not be construed to mean that one particular factor analytic solution is superior to others in establishing construct validity, but rather that any particular solution should be designated with care, taking into account both the nature of the theory or construct upon which the instrument is based, as well as the purpose of the analysis which is being contemplated. The results of this study do clearly demonstrate that selection of the appropriate solution can have substantive effects on the evidence of an instrument's construct validity. In this case, the common factor solution resulted in subscales with (a) more homogeneous content; (b) fewer items keyed to multiple subscales; and (c) greater internal consistency.

A second major implication of these results is directed to users of the HISM scale. Because the HISM is widely used in evaluation of a variety of educational programs, users may find the subscale structure, suggested by this study, helpful. The improved logical consistency of items on the subscales are a definite aid to clear interpretation. This has been recognized by the scale's original author and the revised HISM manual (Gordon et. al., in press) will recommend the use of the new subscales, based on the common factor solution.

Table 1

Comparison of HISM Subscale Content Based on Principal Component and Common Factor Analyses for Girls, Grades 3-6, (N=2,040)

Subscale	Items Assigned Through Common Factor Solution	Items Assigned Through Prin. Comp. Solutions*
Physical Appearance	(7 items)	(8 items)
	My hair is nice looking.	X
	My face is pretty.	X
	I'm just the right weight.	X
	I like the way I look.	X
	My skin is nice-looking.	X
	My clothes are nice.	X
	I'm happy with the way I am built.	X
		Girls like me. ?
Academic Adequacy	(6 items)	(6 items)
	I do well in school work.	X
	I'm very good at making things with my hands.	--
	I'm real good in arithmetic.	X
	I'm smarter than most of the others.	X
	I read very well.	X
	I learn new things easily.	X
		My skin is nice looking. ?
Teacher-School Adjustment	(7 items)	(6 items)
	Teachers like me.	X
	I get along well with teachers.	X
	I do well in schoolwork.	X
	I write well.	
	I use my time well.	
	School is very interesting.	X
	I like school.	X
		I like teachers.
Social Confidence (originally labeled "Interpersonal Adequacy" by Yeatts)	(9 items)	(17 items)
	I stay with something til I finish.	X
	I like to work with others.	X
	I play games well.	X
	I like to try new things.	X
	I like teachers very much.	X
	I want the girls to like me.	X
	School is very interesting. ?	X ?
	I'm happy with the way I am.	X
	My clothes are nice. ?	X ?
		I feel at ease inside.
		I seldom worry.
		The girls like me.
		I control my feelings well.
		I'm good at making things with my hands. ?
		I'm a very good reader. ?
		I learn new things easily. ?
		I like the way I look. ?

Table 1 (cont'd.)

Subscale	Items Assigned Through Common Factor Solution		Items Assigned Through Prin. Comp. Solutions*
Emotional Adjustment	(4 items)		---
	I seldom worry. (I worry a lot.)		
	The girls like me. (The girls don't like me.)		
	I feel at ease inside.		
	I can handle my feelings.		
	(7 items)		---
	I have lots of energy.	?	
	I'm very healthy.	?	
	I do well in schoolwork.		
	I write well.		
	I use my time well.		
	I want the boys to like me.	?	
	The boys like me a lot.	?	

*--An (X) indicates that the items was assigned to this subscale.
A dash (--) indicates that the item was not assigned to this subscale.

Table 2

Comparison of HISM Subscale Content Based on Principal Component and Common Factor Analyses for Boys, Grades 3-6, (N=2,177)

Subscale	Items Assigned Through Common Factor Solution	Items Assigned Through Prin. Comp. Solutions*
Physical Appearance	(7 items)	(8 items)
	I'm just the right height.	--
	My hair is nice-looking.	X
	My face is good-looking.	X
	I like the way I look.	X
	My skin is nice-looking.	X
	My clothes are nice.	X
	I'm happy with the way I am built.	
		I'm just the right weight.
		Girls like me. ?
Academic Adequacy	(5 items)	(6 items)
	I do well in schoolwork.	X
	I'm real good in arithmetic.	X
	I'm smarter than most of the others.	X
	I read very well.	X
	I learn new things easily.	X
		My skin is nice-looking. ?
Teacher-School Adjustment	(6 items)	(6 items)
	Teachers like me.	X
	I get along well with teachers.	X
	I like teachers.	X
	I do well in school work.	X
	School is very interesting.	X
	I like school.	X
Social Confidence (originally labeled "Interpersonal Adequacy" by Yeatts)	(6 items)	(17 items)
	I like to work with others.	X
	I play games very well.	X
	I like teachers very much.	X
	I feel at ease inside.	--
	School is very interesting. ?	X ?
	My clothes are nice. ?	X ?
		I like to try new things.
		I stay with something til I finish.
		I'm happy with the way I am.
		I seldom worry.
		The girls like me.
		I want the girls to like me.
		I control my feelings well.
		I'm good at making things with my hands. ?
		I feel at ease inside.
		I'm a very good reader. ?
		I learn new things easily. ?
		I like the way I look. ?

Table 2 (cont'd.)

Subscale	Items Assigned Through Common Factor Solution	Items Assigned Through Prin. Comp. Solutions*
Boys-Social (or Virility)	(6 items)	(5 items)
	I have lots of energy.	X
	I do well in schoolwork. ?	X ?
	I want the boys to like me.	X
	I'm very healthy. (I get sick a lot.)	--
	I use my time well. ?	--
	The boys like me a lot.	X
		I get along well with teachers.
Girls-Social	(3 items)	(5 items)
	The girls like me a lot.	X
	I'm very good at speaking before a group.	--
	I'm a very good dancer.	X
		I like teachers.
		I want the girls to like me.
		I learn new things easily. ?

*--An (X) indicates that the items was assigned to this subscale.
A dash (--) indicates that the item was not assigned to this subscale.

Table 3

Internal Consistency Estimates*
for HISM Subscales for Females, Grades 3-6, (N=174)

Subscale Name	Subscales Created by Principal Component Solution			Subscales Created by Common Factor Solution		
	No. Items	Actual r_{α}	Projected r_{α} for 10 Items	No. Items	Actual r_{α}	Projected r_{α} for 10 Items
Physical Appearance	8	.69	.73	7	.70	.77
Acad. Adequacy	6	.57	.69	6	.60	.71
Teacher-School Adj.	6	.65	.76	7	.64	.72
Social Confidence	17	.71	.59	9	.65	.67
Emotional Adj.	--	--	--	4	.24	.44
General Adj.	--	--	--	7	.44	.53

*--Computed using Cronbach's alpha.

Table 4

Internal Consistency Estimates*
for HISM Subscales for Males, Grades 3-6, (N=274)

Subscale Name	Subscales Created by Principal Component Solution			Subscales Created by Common Factor Solution		
	No. Items	Actual r_{α}	Projected r_{α} for 10 Items	No. Items	Actual r_{α}	Projected r_{α} for 10 Items
Physical Appearance	8	.62	.67	7	.58	.66
Acad. Adequacy	6	.59	.71	5	.62	.77
Teacher-School Adj.	6	.69	.79	6	.69	.79
Social Confidence	17	.70	.59	6	.56	.68
Boys-Social	5	.52	.68	6	.55	.67
Girls-Social	5	.44	.61	3	.46	.74

*--Computed using Cronbach's alpha.

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